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Clinical features of electric powered indoor/outdoor wheelchair users with spinal cord injuries: A cross-sectional study

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ABSTRACT

This article aims to describe the characteristics of those with a primary diagnosis of spinal cord injury (SCI) attending a specialist wheelchair service providing electric powered indoor/outdoor chairs (EPIOCs). This cross-sectional study, with retrospective review of electronic and case note records, explores the complexities of additional clinical features associated with SCI and disability influencing prescription. Data were extracted under three themes; demographics, diagnostic/clinical information and wheelchair factors. There were 57 participants (35 men, 22 women) (mean age 53.51 ± 11.93, range 29–79 years) comprising 20 with paraplegia, 34 with tetraplegia and 3 with undocumented level. Paraplegics were significantly older than tetraplegics ($p < 0.05$). Thirty users had a complete SCI (mean age 49.87 ± 12.27 years) and 27 had another SCI lesion (mean age 57.56 ± 10.32 years). Those with a complete SCI were significantly younger than the rest ($p < 0.02$). Only 10 (9 tetraplegic) had SCI as the sole diagnosis. Twenty (15 tetraplegic) had one additional clinical feature, 14 had 2–3 (6 tetraplegic) and 13 (4 tetraplegic) had 4 or more. Ten users required specialised seating, 22 needed tilt-in-space EPIOCs while six required complex controls. The range and complexity of wheelchair and seating needs benefitted from a holistic assessment and prescription by a specialist multidisciplinary team.

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KEYWORDS
mobility; neuromuscular impairment; service delivery; wheeled mobility aids

Introduction

The picture of spinal cord injury (SCI) is changing with increased age of injury, more cervical level SCIs and fewer neurologically complete lesions in those with traumatic injury (De Vivo 2012) and an increasing prevalence of non-traumatic SCI accompanied by progressive diseases requiring complex health interventions (Bickenbach et al., 2013). Epidemiological studies have reported that the mean age of SCI in the United States population is 45.4 years, with an increase in new SCI in those aged 60 and over and longer life expectancy for those with paraplegia (DeVivo, 2012). For individuals who have experienced a SCI, functional outcomes are influenced mainly by the level of the spinal injury (Kirshblum et al., 2007) and may be additionally influenced by associated factors, such as age and the presence of other medical conditions (comorbidities) (Chiodo et al., 2007).

Electric powered wheelchairs are likely to be required by those with cord lesions at C1-4, C5 and C6, with those with C1-4 lesions recommended to be provided with chairs with tilt functions (Kirshblum et al., 2007). It has been reported that while 95% of people with paraplegia use manual wheelchairs, 45% of those with tetraplegia use electric powered wheelchairs (Chaves et al., 2004). Overall, approximately 27% of people with SCI use electric wheelchairs as well as using other mobility aids (Biering-Sorensen et al 2004).

The complex interplay between the needs of an individual with a SCI, the available assistive technology and the challenge of the environments within which the user and chair need to operate successfully are often discussed (Minkel, 2000) but little is known about how electric powered wheelchair providers respond to the mobility needs of those whose dominant clinical condition presents as a SCI.

In the United Kingdom (UK) electric powered indoor/outdoor chairs (EPIOCs) funded by the National Health Service (NHS) can be provided to individuals who meet strict eligibility criteria, including inability to self-propel, and who are able to benefit from provision of an electric powered wheelchair (Frank, Ward, Orwell, McCullagh, & Belcher, 2000). Those attending a wheelchair service with uncomplicated paraplegia, able to use their upper limbs and maintain trunk position, are unlikely to meet the criteria for provision of an EPIOC. Individuals with a SCI who are provided with an EPIOC are likely to have severe disabilities that are long term and established resulting in complex clinical needs. For some, these needs may follow prolonged periods of self-propelling complicated by, for example, shoulder pain (Curtis et al., 1999). For others, such as older adults, limited upper body strength may indicate the need for an electric powered chair (Florio, Arnet, Gemperli, & Hinrichs, 2016) yet research into age-related health issues in electric powered wheelchair users with SCI remains sparse. For some individuals, the SCI is non-traumatic and may result from defined pathology involving the spinal cord, for example a tumour. While it has been shown that those with a non-traumatic and

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predominately incomplete SCI tend to be older than those with a traumatic SCI (New, Rawicki, & Bailey, 2002) it is unclear if this is reflected in electric powered wheelchair users although the average age of manual wheelchair users with paraplegia and shoulder pain is reported at 49 ± 18 years (Samuelsson, Tropp, & Gerdle, 2004). Clinical factors such as pain and fatigue are reported to limit activity in wheelchair users with SCI, those with paraplegia being more frequently affected than those with tetraplegia (Chaves et al., 2004).

Subjective pain experience is reported to affect 64%–80% of the SCI population (Chiodo et al., 2007). A recent systematic review of pain in SCI reported that the prevalence of chronic musculoskeletal pain was 49%, chronic back pain was 47% and chronic low back pain was 49% (Michailidou, Marston, De Souza, & Sutherland, 2014). The review recommended that posture and seating, along with interventions for pain relief, should be considered as part of the rehabilitation process (Michailidou et al., 2014). In EPIOC users, marked changes in the experience of pain can occur during the day (Frank, Spyridonis, & Ghinea, 2015) and may be influenced by a variety of factors including performance of everyday activities, poor posture, ineffective use of medication or simply the pain associated with the underlying disorder (Frank, De Souza, Frank, & Neophytou, 2012).

Further limitations may impact on individuals due to secondary medical conditions that are commonly associated with SCI and these should be taken into account when providing electric powered mobility. Pressure injuries are the most often reported complication of SCI (Chiodo et al., 2007). Respiratory complications are frequent in those who are older and/or have a tetraplegia (McKinley, Jackson, Cardenas, & DeVivo, 1999) and bladder and bowel complications are fairly ubiquitous in SCI (Chiodo et al., 2007). Some secondary medical conditions relate to the time since injury (e.g. pressure injuries), the level of the SCI (e.g. pneumonia), completeness of injury (e.g. pain) (McKinley et al., 1999) and age (e.g. heart disease) (DeVivo, 2012) amongst other factors. Due to the ambiguity of categorising these conditions as co-morbidity, a corollary of the SCI, or a feature of long-term severe disability, they have been referred to collectively as additional clinical features (ACFs) (De Souza & Frank, 2015).

Electric powered wheelchairs are not only important in their ability to enhance personal independence and participation but are now also considered to be significant therapeutic tools (De Souza & Frank, 2015, 2016; Dicianno et al., 2015). Features such as specialised seating (SS) (to promote an optimal seating posture and enhance comfort) and tilt-in-space (TIS) (for pain control, pressure reduction and fatigue management) are transforming the lives of EPIOC users who may sit in their chairs for up to sixteen hours a day (Frank et al., 2012).

The aim of this research is to describe the clinical features and demographics of adult EPIOC users with spinal cord injuries and how these are related to prescription of specialised seating (SS) and tilt-in-space (TIS) chairs. A further aim was to compare age differences between users with paraplegia and tetraplegia, and users with complete SCI and other SCI lesions.

Methods

This is a cross-sectional study of a clinic sample with retrospective review of clinic and case note records. These records were reviewed by a consultant in rehabilitation medicine from June 2007 to September 2008 to check the clinical information. The study was approved by the National Research Ethics Service as a service evaluation. The full cohort of EPIOC users has been published elsewhere (Frank & De Souza, 2013) and this study presents a sub-group analysis of those with a primary diagnosis of SCI.

Participants

Individuals with a primary diagnosis of a SCI referred for EPIOC assessment from their local wheelchair service to a specialist regional wheelchair service were potential study participants. The regional service covered a mixed population of approximately 3.1 million living in inner city, suburban and rural communities. EPIOC provision was limited to those who were unable to walk safely around their own home, unable to self-propel and were judged safe to use their chairs in public places (Frank et al., 2000). Details of the clinical service are provided elsewhere (De Souza & Frank, 2015; Frank et al., 2000). All individuals with a diagnosis of a SCI living in the community who had been prescribed an EPIOC and were currently using their chair at the time of this retrospective review were of interest to this study.

The clinical decision pathway for EPIOC provision comprised four phases.

(1) The local wheelchair provider completed a screening questionnaire.
(2) Assessment by an occupational therapist for suitability of the home environment and likelihood of the individual meeting the eligibility criteria for an EPIOC (Frank et al., 2000; p. 672).
(3) Assessment by the specialist regional wheelchair service multidisciplinary team included medical history and social situation. Each person was weighed and a physical examination conducted in lying and sitting positions to identify any issues relating to posture/seating or wheelchair control. Transfers were observed for safety and to identify problems relating to pain and/or spasticity and examination of visual fields was carried out. An EPIOC driving assessment was conducted indoors and outside. It included negotiating kerbs, crossing the road and manoeuvring around obstacles. Safety of the EPIOC user and others while driving the chair was considered (Frank et al., 2000; p. 672).
(4) The EPIOC was delivered by a rehabilitation engineer from the specialist regional wheelchair service who explained the use of the chair, checked seating and the user's ability to drive outdoors and in their home.

All wheelchair users who met the criteria for EPIOC provision following assessment (Frank et al., 2000) were prescribed

the most appropriate EPIOC and cushion for their needs and those with a primary diagnosis of a SCI were included in this study. They were living in the community and were using their electric powered wheelchairs at the time of the study.

Procedures

Data were obtained from two sources, the electronic records and medical records (clinical charts). The electronic records provided demographic information, clinical information and details of the equipment supplied. Demographic information consisted of age and sex at initial assessment at the specialist regional wheelchair centre. Clinical information included the primary diagnosis and additional clinical features (ACFs) that included comorbidities, corollaries of SCI and complications relating to the disability noted by health professionals at the specialist regional wheelchair centre. These will be referred to as ACFs hereafter. The equipment details comprised EPIOC wheelchair factors including use of special seating (SS) (adaptive seating), defined as 'that which is needed by people who require a wheelchair but due to instability or deformity need additional support in order to function' (British Society of Rehabilitation Medicine, 2004, p. 7), tilt-in-space (TIS), cushions and complex controls. These data had been entered into the electronic records by health professionals following a multi-professional physical assessment and examination.

Data extracted from the medical records comprised details of the assessment process. This included the diagnosis leading to the need for an EPIOC, ACFs, relevant clinical and social history, and details of the clinical assessments carried out. Additional information considered to be relevant to the prescription of an EPIOC included ACFs which had been revealed during the assessment process and noted in the medical records. Problems associated with the current seating provision and cushions were reviewed and clinical details relevant to EPIOC provision were recorded.

Spasticity is a common feature of SCI. For the purpose of this research, spasticity was noted as 'problematic' when it interfered with the EPIOC prescription (e.g. stability in the chair), or posed an increased risk of contracture or pressure injury or musculoskeletal deformity and dysfunction (Sezer N et al 2015). Pain is a frequent aspect of SCI often going untreated (Brinkhof et al 2016). In our study, individuals with inadequately controlled pain needing further investigation/management or influencing the EPIOC provision were noted as having 'problematic pain'. Users who reported that spinal surgery had aggravated or caused their symptoms where recoded as having had 'failed spinal surgery'.

Data were systematically extracted, anonymised by removing all personal identification details (names, addresses, and any unique identifier, e.g. hospital number) and entered into a computer database. Data were organised under three themes; demographic, clinical and diagnostic information and wheelchair/seating factors. The average time from EPIOC provision to case note review was 57.5 (range 2–122) months.

Methods of analysis

Descriptive statistics were used to analyse demographic data (age and sex). Clinical and diagnostic data were analysed by type and frequency. Equipment data were analysed to describe proportions and frequencies of variables relating to wheelchair factors and specialised seating provision. Age differences between users with paraplegia and tetraplegia, and users with complete SCI and other SCI lesions were analysed using unpaired two-tailed *t*-tests.

Results

Demographics

There were 57 EPIOC users (35 men, 22 women) with a primary diagnosis of a SCI (mean age 53.51 ± 11.94, range 29–79 years). The group comprised 20 (35%) (10 men) with paraplegia (mean age 58.05 ± 12.26 years), 34 (60%) (24 men) with tetraplegia (mean age 51.44 ± 11.17 years) and 3 (1 man) with indeterminate level of SCI (two postsurgical SCI following tumour removal; one SCI following back surgery) (Table 1).

Paraplegics were significantly older than tetraplegics (n = 54; t = 2.02576; p = 0.048). Using the age categories described by Warren (Warren, 1989), 30 (aged 25–54 years) could be described as those developing families, jobs, and careers, 25 (55–74 years) were those reaching the end of employment and in active retirement, and 2 (> 75 years) were older adults.

Thirty users (18 men) had a complete SCI (mean age 49.87 ± 12.27 years) and 27 (17 men) had another SCI lesion (mean age 57.56 ± 10.32 years). Users with a complete SCI were significantly younger than those with other spinal cord lesions (n = 57; t = -2.54388; p = 0.014).

Diagnostic and clinical information

Only 10 users (9 tetraplegic, one caused by a congenital arterio-venous malformation) had SCI as the sole diagnosis with no additional clinical features. Twenty (15 tetraplegic)

Table 1. Demographic and diagnostic and additional clinical features of 57 EPIOC users with spinal cord injury, use of specialised seating and tilt-in-space chairs.

	Paraplegia (n = 20)	Tetraplegia (n = 34)	Unknown (n = 3)	Total (n = 57)
Male:Female	10:10	24:10	1:2	35:22
Age (mean± SD)	58.05 (± 12.26)	51.44 (± 11.17)	46.47 (± 12.5)	53.51(± 11.94)
SS	3	5	2	10
TIS	7	13	2	22
1 ACF	4	15	1	20
2–3 ACF	8	6	0	14
4–6 ACF	7	4	2	13

Key: SS = specialised seating; TIS = tilt-in-space; ACF = additional clinical features

had one ACF 14 (6 tetraplegic) had 2–3 and 13 (4 tetraplegic) had 4 or more (Table 1). The total count of ACFs for the 47 users was 115 (Table 2). The 35 men had an average 1.5 (± 1.6) ACFs and the 22 women an average of 2.8 (± 1.4).

The most commonly noted ACFs were low back pain (n = 10), failed spinal surgery (n = 8), (kypho)scoliosis (n = 8), problematic pain (n = 6), shoulder pain (n = 6) and ischaemic heart disease, neck pain and pressure injury (n = 5 for each ACF) (Table 2). All five users with pressure injuries had three or more ACFs. In addition, three users were noted as needing immediate pressure reduction intervention. Two had tetraplegia with three and one ACFs respectively and one had an incomplete paraplegia and three ACFs.

Upper limb/neck problems were noted for 16 users (nine tetraplegic). Five users (three tetraplegic) had neck pain with/without radiculopathy. Two users had brachial plexus lesions (one tetraplegic). Two paraplegic users had forearm/digit amputations. Six users had problematic shoulder pain (four tetraplegic) including one tetraplegic user who had carpal tunnel syndrome and surgical intervention for a painful shoulder (Table 2).

ACFs affecting the brain were recorded for six users (three with cerebrovascular disease, two with traumatic brain injury and one with epilepsy) (Table 2). One user had an ependymoma (removed but remnants remained slowly growing) and required ventilatory support to be mounted on the EPIOC.

Table 2. Frequency of the occurrence of additional clinical features in 57 EPIOC users with a spinal cord injury.

Additional Clinical Features	Frequency
Neurological Features (total)	**12**
Cerebrovascular disease	3
Traumatic brain injury	2
Brachial plexus injury	2
Problematic spasticity	2
Other [a]	3
Pain Conditions (total	**29**
Back pain	10
Neck pain	5
Problematic pain	6
Shoulder pain	6
Other [b]	2
Musculoskeletal features (total)	**30**
(kypho)Scoliosis	8
Previous (failed) spinal surgery	8
Osteoarthritis	4
Fractures	4
Amputation	2
Osteoporosis	2
Hip problems	2
Cardiac and pulmonary features (total)	**11**
Ischaemic heart disease	5
Recurrent chest infections	2
Other [c]	4
Pressure Injury (total)	**5**
Bladder and Bowel Features [d] ***(total)***	**4**
Other clinical features (total)	**24**
Diabetes	4
Dependent oedema/cellulitis	4
Cancer	3
Tuberculosis	2
Achondroplasia	2
Hearing impairment	2
Obesity	2
Other [e]	5
Total	***115***

Key: [a] Epilepsy, congenital arteriovenous malformation, syringomyelia. [b] Ankle pain, carpal tunnel syndrome. [c] Hypertension, asthma, hypotension, ventilatory failure. [d] Diverticular disease, constipation, urinary tract infections, renal disorder. [e] Anaemia, weight gain, depression, parathyroid disorder, thyroid disorder.

Medical issues requiring further attention from their family doctors (primary care team) were identified by the specialist wheelchair service health professionals in 18 (32%) users during the assessment process for EPIOC prescription. The need for pain management was the most common (n = 8). A variety of other medical issues noted during assessment included poorly controlled spasticity, chest infection, obesity, postural oedema and constipation. Three individuals were assessed as 'at risk' during transfers, having inadequate home support and requiring social care. The individuals were referred back to their family doctors for management of these medical issues.

Wheelchair factors and seating

Tilt-in-space chairs were provided to 22 (13 tetraplegic) EPIOC users. Of these 22, four (three tetraplegic) had no ACFs, six (three tetraplegic) had one ACF, two (both tetraplegic) had two ACFs, three (all paraplegic) had three ACFs and seven users (five tetraplegic) had 4 or more ACFs.

Ten users (five tetraplegic) required specialised seating (matrix = 3, carved foam = 2, specialised seating with a pressure relieving cushion = 5) (Table 1). Of these ten, two (one paraplegic, one tetraplegic) had incomplete lesions and no ACFs. Three users had one ACF, one had two, one had three and three users had four ACFs. Four users (three tetraplegic; one with meningioma) were provided with both tilt-in-space chairs and specialised seating. Of the 47 EPIOC users not provided with specialised seating, 25 (53%) had no or only one ACF, 12 (26%) had 2–3 AFCs and 10 (21%) had 4 or more ACFs.

Standard wheelchair cushions (foam cushion with a wipe clean covering) were supplied to 15 users. The remainder were provided with pressure-reducing cushions mainly Jay 2 cushion (n = 11), Qbitus (n = 9), Vicaire (n = 5), Roho (n = 4) and others (n = 2). One user utilised the voucher scheme (Frank, Ellis, & Yates, 2008) to purchase their chair independently, and therefore the cushion type was not known.

Six users (11%) (five tetraplegic) required complex/bespoke control systems and two required their system to interface with other electronic/electrical assistive technology devices (e.g. environmental control units). The reasons for prescribing complex and non-standard control units were severe upper limb weakness (four users), co-existing head injury (one user) and co-existing respiratory insufficiency with progressing cancerous tumour (one user). Referrals for environmental control units were made for a further two users.

Discussion

Electric powered wheelchair users may represent only about 27% of people with SCI (Biering-Sørensen et al 2004) and this study is the first to describe a group of SCI individuals, irrespective of age, prescribed an EPIOC. It highlights the impact of additional clinical features associated with SCI or due to long term disability or comorbidity that potentially influence the EPIOC prescription. These issues may be critical for service funders.

Demographics

In our study, as may be expected, the majority of EPIOC users with SCI were tetraplegic (60%), a proportion comparable to the study of Biering-Sorensen et al (2004) which found 62% of electric wheelchair users had SCI at cervical levels 1–8. Unlike other groups of SCI manual wheelchair users those with a paraplegia fulfilling EPIOC criteria were found to have a range of neck and upper limb impairments. These ACFs are likely to prevent them from self-propelling effectively.

The mean age of the study group is similar to that reported by other studies on individuals with SCI using assistive technology for mobility (Floria et al 2016; Jain, Higgins, Katz, & Garshick, 2010) and specifically SCI users of electric wheelchairs (Biering-Sørensen et al 2004), but older than population-based samples of people with SCI (Brinkhof et al 2016, Martin Ginis et al., 2010).

Our findings demonstrate that, in our sample, those with a complete SCI were significantly younger that those with other spinal cord lesions and reflect similar findings by (New et al., 2002). This may reflect the reports of increasing incidence of SCI in those over 60 years due to falls and accidents and a trend towards increases in incomplete injury (DeVivo, 2012). In our sample, we found that EPIOC users with paraplegia were significantly older than those with tetraplegia and noticeably older than a general population with SCI (DeVivo, 2012) and manual wheelchair users with paraplegia (Samuelsson et al., 2004) It is likely that those with paraplegia need powered mobility later in life as changes in upper limb strength and function become compromised due to ageing taking a toll, as suggested by Florio et al. (2016) and/or to developing shoulder impairments (Jain et al 2010), median nerve injury or overuse injury from self-propelling. Further longitudinal studies are needed to examine the main reasons why people with SCI need to transition from manual to electric powered wheelchair use.

Additional clinical features

Several additional clinical features found in this group of EPIOC users have a direct influence on the wheelchair prescription, for example amputation or brachial plexus injury. Others are likely to affect the health and wellbeing of the individual, but may have little or no impact on the EPIOC provision, e.g. anaemia. Our finding that the majority SCI EPIOC users had multiple additional clinical features reflects reports from other SCI populations (New et al., 2002) although in our group a higher proportion had two or more additional conditions which indicate the severity of disability in EPIOC users.

A number of health conditions were noted that might reasonably be expected to be aggravated by long-term manual wheelchair use. Those, such as scoliosis and pressure injuries, need specific consideration for appropriate seating and cushions. Others, such as obesity and weight gain are known risks for people with SCI who are dependent on wheelchairs (Crane, Little, & Burns, 2011). This is similar to wheelchair users with other long term conditions such as multiple sclerosis (De Souza & Frank, 2015).

Nearly 10% of this cohort had definite existing pressure injuries, with a further three individuals at immediate risk of developing a pressure injury. Pressure injuries, oedema/cellulitis and osteoporosis are all preventable complications of disability and the occurrence of these additional clinical features were noted in this cohort. This finding underlines the seriousness of these complications for individuals and vigilance is required to monitor those who have such complications and to identify those at risk of developing them. Our finding that those with pressure injuries had three or more ACFs concurs with reports that, in addition to lack of pressure reduction and poor sitting posture, other clinical issues such as (kypho)scoliosis, (Minkel, 2000), and obesity (Elsner & Gefen, 2008) increases risk of pressure injury development.

In this group, we found eight (14%) individuals who had experienced a poor (failed) outcome from spinal surgery. Surprisingly only a minority had problematic pain or were provided with TIS. However, our group of 57 SCI EPIOC users experienced a variety of painful conditions and at least six users experienced poorly managed pain that required further clinical intervention. Back pain and shoulder pain were often noted but to a lesser degree than with other studies on more diverse SCI groups (Jensen, Hoffman, & Cardenas, 2005). This is probably due to EPIOC users not needing to self-propel and the attention given to seating support and comfort as well as the provision of tilt-in-space, which is known to provide relief for pain and fatigue (Dicianno et al., 2015; Frank et al., 2012). In our study, however, the issues regarding pain and its management through appropriate EPIOC provision requires some discretion as some individuals would have experience of using their EPIOC for several years and others experiences would have been for a few months only.

The co-occurrence of TBI with SCI is reported to be 60%, although most are considered to be mild in nature (Macciocchi, Seel, Thompson, Byams, & Bowman, 2008). Our study found only two EPIOC users with both SCI and TBI, which is atypical. The probable reason is that those with cognitive impairments, behavioural issues and uncontrolled epilepsy are likely to be ineligible for EPIOC provision on the grounds of safety. It is also possible that the medical records had not noted TBI or that it had not been assessed for adequately.

In this study, we found additional clinical features that may be associated with ageing, such as osteoarthritis and ischaemic heart disease, and this may add to evidence that people with SCI experience 'accelerated ageing' (Charlifue, Jha, & Lammertse, 2010). However, this finding may also be due to long term disability and wheelchair use as similar co-morbidities have been reported for EPIOC users with multiple sclerosis (De Souza & Frank, 2015) and cerebral palsy (Frank & De Souza, 2017). This cohort are older than population-based groups of people with SCI and similar to reports of older people with SCI and parallel medical conditions such as heart disease, diabetes and obesity (DeVivo, 2012) which were also found in our EPIOC users.

Wheelchair features and seating

In this study, tilt-in-space chairs were provided to almost 40% of the cohort and specialised seating to about 18%. These

findings were comparable to a similarly aged cohort of multiple sclerosis EPIOC users (De Souza & Frank, 2015).

Tilt is an essential therapeutic strategy for those who spend many hours in their chairs and who have little ability to change position (Sonenblum and Sprigle 2011). In our study, over half provided with TIS had tetraplegia where use of the upper limbs to contribute to pressure relief would be limited. In addition, 82% with TIS had ACFs, with 32% having four or more ACFs indicating the complex needs of those with both a SCI and a range of other health conditions requiring EPIOCs. The major clinical reasons to provide tilt are to support pressure reduction, reduce pain and improve comfort (Ding et al., 2008; Frank et al., 2012; Lacoste, Weiss-Lambrou, Allard, & Dansereau, 2003). In addition, frequent small tilts are also reported to increase blood flow for people with SCI (Sonenblum and Sprigle 2011) and greater tilt, with recline, increases skin blood perfusion over the ischial tuberosities (2013; Dicianno et al., 2015; Jan, Brienza, Boninger, & Brenes, 2011). Clinical reasons why tilt may not be prescribed include cautiousness for individuals with an indwelling catheter as tilt can cause backflow of urine (Dicannio et al 2015).

Specialised seating is essential for those who need it as the seated position forms a foundation from which people with SCI can carry out activities of daily living (Minkel, 2000). The lower proportion of SCI users needing specialised seating in this study (18%) would indicate that the majority had sufficient residual upper limb and upper trunk voluntary function to enable them to use standard equipment. The proportion is similar to EPIOC users with multiple sclerosis (16%) who are also reported to utilise residual upper limb and upper trunk voluntary function (De Souza & Frank, 2015). The proportions of ACFs noted for those who did receive SS and those who did not need SS are relatively comparable indicating that reasons for SS are likely to be due to the clinical implications of the SCI such as posture (Minkel, 2000) rather than due to ACFs. The result may also reflect the assessment and prescription procedure of the specialised unit and/or the individual preferences of EPIOC users. The high frequency of provision of pressure reducing cushions indicates attention to the importance of pressure area care and reduction in the risks of pressure injuries developing (Sezer et al., 2015), as recommended by current guidelines (Consortium for Spinal Cord Medicine, 2014; National Institute for Health and Care Excellence 2014). An appropriate combination of a pressure reducing cushion and tilt-in-space chair can be a useful strategy for maintaining tissue integrity of the buttocks (Consortium for Spinal Cord Medicine, 2014) especially for those who are unable to push-up or physically shift their weight to relieve pressure.

The provision of complex controls were proportionately greater for SCI (11%) compared with MS users (2%) (De Souza & Frank, 2015). This was accounted for by the higher level of impairment of tetraplegic users and/or insufficient upper limb strength and function. Inability of EPIOC users with SCI to use a standard joystick control may be due to insufficient strength in the hands, lack of flexion and extension in wrists and fingers, or severe fatigue (Urbano, Fonseca, Numes, & Figueiredo, 2008). In addition, the need to adapt the control system to interface with other assistive technology (e.g. environmental control systems or communication systems) must be considered in order to facilitate independent living.

Strengths and limitations

As may be expected, a strength of this study was that all users were assessed by the same multi-professional team who were very experienced in the provision of electric powered wheelchairs therefore the clinical decisions made were consistent and in accordance to service protocols. Those decisions were recorded at the time in clinical records and notes. Therefore a further strength was that this study did not rely on EPOIC users' self-reports as we utilised chart review and clinical assessment as recommend by Brinkhof et al (2016). We recognize that the presence of additional clinical features is likely to be underreported as diagnostic data were obtained from referral letters and patient histories. However, such data are more likely to be objective than purely patient self-report surveys. As case note reviews are likely to be less comprehensive than prospective data, further prospective studies are recommended.

Our study is limited by relatively small numbers of EPIOC users in this cohort who represent a minority group of the total SCI population (Biering-Sørensen et al 2004) and we included only those who were provided with electric powered chairs for both indoor and outdoor use. They had different experiences of using electric powered mobility as some had just a few months of EPIOC use and others had several years of experiencing electric powered mobility. It is possible that an optimum EPIOC prescription had yet to be agreed between user and service provider for those new to operating with their chairs in daily life and ACFs such as pain and discomfort may have required longer EPIOC use to be resolved. We did not study those who purchased electric powered wheelchairs privately or with charitable funding. We also did not study those who use scooters.

Conclusion

The needs of those with SCI referred for electric powered wheelchair provision suggest an often complex situation, as evidenced by the participants in this study. Findings suggest that support focussing on the individual, rather than on their injury alone, should incorporate the variety and range of additional clinical features that are important for type of chair and seating provision. Those with upper limb involvement due to the spinal injury, and/or additional clinical features had complex needs that were accommodated through suitable EPIOC and seating provision. Achieving an appropriate prescription of assistive technology to support independence has funding implications, yet is essential for maintaining community living for those with SCI and severe mobility disability. The provision of an EPIOC and appropriate seating can optimise the therapeutic role of electric powered wheelchairs in the clinical management of those with severe and enduring mobility disability in addition to enhancing mobility, independence and participation.

Our findings also identified serious clinical conditions that needed urgent attention such as problematic pain, pressure

injuries and uncontrolled spasticity indicating that on-going vigilance for these common complications is warranted to safeguard EPIOC users' wellbeing. Further research is needed to establish the long-term impact on and risk to health in SCI EPIOC users of co-occurring conditions such as osteoporosis, cardiovascular disease, diabetes and osteoarthritis, especially as the community dwelling SCI population ages.

Disclosure statement

No potential conflict of interest was reported by the authors.

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